INSTITUTION NOTES

September 1941

Fixtures.

26th September.—Annual Luncheon of the Institution, Grosvenor House, London, 1 p.m.

27th September.—North Eastern Section, Newcastle-on-Tyne, 3 p.m., lecture by Dr. Geo. Schlesinger on "Higher Education for Production Engineers."

14th October.—Coventry Section, lecture by Dr. Geo. Schlesinger on "Surface Finish."

15th October.—Annual Meeting of the Standing Committee on Research, London, 2-30 p.m. Meeting of the Joint Research Committee of the Institution and the Institution of Mechanical Engineers, 11-30 a.m.

18th October.—Yorkshire Section, Huddersfield, Lecture by Dr. Geo. Schlesinger, on "Surface Finish." Members of the Institution of Mechanical Engineers are invited to attend this meeting.

6th November.—Annual General Meeting of the Institution, London 11-30 a.m.

Higher National Certificates in Production Engineering.

The Joint Committee dealing with the scheme met in London on 10th September, the Institution representatives being Mr. J. W. Berry, Mr. James France and the General Secretary. The Joint Examination Board of the Institution also discussed the scheme at its meeting on 6th September in Birmingham. The preparation of Production Engineering Courses designed to cater for the Certificate is now proceeding at numerous Technical Colleges. There is already evidence that, in spite of war conditions, the scheme will meet with wide support.

Section Honorary Officers.

Mr. A. E. Newby has succeeded Mr. F. C. Laws as President of the Eastern Counties Section, and Mr. C. F. Gazard is Chairman of the Birmingham Graduate Section for 1941-42, in succession to Mr. W. A. Robinson.

Subscriptions for Research Department.

Subscriptions towards the work of the Institution's Research Department have been received since those announced last month, as follows :—

	£	s.	d.
Murex, Ltd.	100	0	0
Newton Chambers, Ltd.	100	0	0
Catmur Machine Tool Corporation, Ltd.	52	10	0
Cutanit, Ltd.	50	0	0
A. C. Wickman, Ltd.*	26	5	0
Dennis Bros., Ltd.	25	0	0
Black and Decker, Ltd.	10	0	0
F. W. Cranmer (Member)	2	10	0
B. S. Lewis (Graduate)		10	0

* Additional to £21 5s. 0d. received earlier.

Annual General Meeting : Official Notice.

NOTICE IS HEREBY GIVEN that the Annual General Meeting of the Institution will be held on Thursday, 6th November, 1941, at Institution Headquarters, 36, Portman Square, London, W.1., at 11-30 a.m.

AGENDA :

1.—Notice convening Meeting.

2.—Minutes of previous Annual General Meeting.

3.—Report on Election of President and Members of Council.

4.—Annual Report of the Council and Accounts for the year ended 30th June, 1941.

5.—Election of Auditors for 1941-42.

6.—Votes of thanks to Lecturers and Section Hon. Secretaries.

By Order of the Council,
RICHARD HAZLETON,
General Secretary.

36, Portman Square,
London, W.1.
24th September, 1941.

Commissions in H.M. Forces.

Considerable numbers of our members have already entered the Commissioned Ranks of H.M. Forces. There are indications that before long there will be a call for further young engineers to join t' Forces, in capacities where their professional knowledge can be utilised.

SOME APPLICATIONS OF COMPRESSED AIR FOR PRODUCTION

Paper presented to the Institution by
D. Braid, A.M.I.P.E.

IN this rather short paper it is hoped to be able to draw attention to a few of the uses of compressed air as applied to a works engaged in production of normal engineering products. Compressed air has many very specialised applications which are rather outside the field of the normal manufacturing programmes but, even to-day, its value for many operations has not been realised by a number of potential users. The keynote for the adoption of this source of power is its convenience and this advantage gives it a considerable lead over alternative methods when certain factors have to be considered. It is speedy, silent, clean, and safe. There is no temperature problem, exhaust pipes are unnecessary, and it is quite safe for use in positions where electrical apparatus would be undesirable owing to the dangerous atmosphere or conditions.

The main advantage and the most important one from the point of view of production is the possibility of reducing the physical effort of operators with the consequent reduction in operational time. Air-operated equipment, in all its many and varied forms, is designed for this purpose, and remarkable results have been obtained. Its value was not appreciated quite as quickly in this country as in the United States, but many of our own engineering concerns have devoted much time and care to developing the many spheres of application.

Compressed air, having virtually no viscosity, enables the designer to provide for operations where high speed of moving parts is necessary and sharp blows whether for riveting or clamping movements.

With the little space that is available to deal with such a wide subject, much has had to be left out, but an endeavour has been made to mention one or two uses which are comparatively recent in origin, and also to provide a few notes on the vexed subject of moisture in compressed air. It has not been possible to find time to prepare a completely new paper so it consists of a number of extracts from the manuscript of a book that has been prepared for publication and acknowledgment is made of the publishers' permission as well as the very valuable help given by several firms.

Stationary cylinders, made in a number of different types and sizes, have a very wide range of uses and for clamping, ejection of

work, and locking of jigs and fixtures, their speed of operation and convenience places them above all other methods.

Cylinders may be purchased from a number of makers who have specialised in this product and are made with feet, lugs, or flanges to suit any particular requirements, or hinges where the cylinder must pivot. Some jig and tool designers prefer to design their own cylinders, incorporated with the fixtures or machines, and in this case it is advantageous to use standard parts which can be kept in stock, such as pistons, glands, etc., which have been made up in reasonable numbers, thus gaining the benefit of batch production. The principle advantages to be gained in this case are compactness and saving of space, but certain points should be carefully watched unless previous experience has been gained in this field.

Most proprietary cylinders are made of cast iron but, for those made to suit a particular job, the built-up type using a steel tube with cast iron end plates is very convenient as the pistons and end plates can be drawn from stock and the tube and piston rod made up according to the stroke required.

The studs should be ample in size or correspondingly increased in number, the latter being the better practice as the smaller stud allows the use of a small pitch circle diameter thus permitting better clamping of the tube in the end plates. In any case, the studs should only be lightly stressed in order to prevent stretching when the air pressure is applied.

Where a honing machine is available and the cylinder can be finished to close tolerances, the use of metal piston rings can be adopted, with a consequent reduction in friction, but rusting up must be watched for if the air contains traces of moisture. It is always advisable to copper plate the component parts of air cylinders or, better still, to cadmium plate them, and in addition to use a compounded lubricating oil with 5% to 10% of fatty acid, as this will combine with the moisture to form an emulsion which will often prevent any rusting.

For small cylinders, a non-ferrous casting will avoid all these troubles and gives the advantage of being a sound casting as well as non-rusting. Where light work of large surface area has to be clamped down for drilling or light milling, a number of these cylinders can be built into the jig providing equalised clamping at all points independent of variations of thickness.

For small units it is usual to provide spring return to the piston but, where heavy moving parts or large cylinders are used, air operation of the return stroke is practically essential and a double acting piston is called for. Where cup washers or rings are used, moulded packing of special composition is recommended as leather tends to harden up and needs taking out and soaking in oil at regular intervals, especially if the cylinder is not in regular use.

As an alternative, a special packing of hemp and asbestos impregnated with graphite may be used so long as care is taken to see that it is not expanded too much, thereby ensuring air tightness but at the expense of excessive friction.

It is always good practice to provide a lubricator in the air supply line, but this can be omitted if other oiling arrangements are employed and the operator is conscientious enough to see that it is carried out at regular intervals.

Air-operated clamping devices cover a very wide field and are continually being applied in new directions as their value becomes more appreciated. The normal use is in connection with jigs or fixtures, but units can be designed for clamping work on to machine beds, reducing handling time considerably, thereby providing additional output which is so very valuable under modern conditions.

Even to-day the scope of air clamping is not fully realised in this country, but in the United States in particular, full advantage is taken of the speed and convenience of being able to apply pressure to a number of points in a fixture simultaneously with one movement of a lever, and to be able to release the work again as rapidly at the conclusion of the operation.

It should always be remembered that one of the greatest advantages of air clamping is in being able to control with exactitude the pressure that is applied and to repeat it as many times as may be necessary, with the same speed, despite variations in size or thickness of the work, and without adjustment. It is also possible to put greater or less pressure at any particular point by varying the diameter of the cylinder compared with those used elsewhere in the same fixture. Another very valuable asset in connection with these clamps is the ease with which it is possible to apply pressure at any point before other clamps are in operation, or while they are only partially applied. This is of particular value where it is necessary to force the work up to one or more location points before finally securing in position, and is more effective than the usual methods, especially where a lead or rubber hammer would otherwise be used to tap the work home against the stops. Progressive control of clamping may be achieved by arranging for a special port in the control valve or by metering the rate at which air is applied to groups or individual cylinders by means of throttling screws on the cylinder inlet ports or in the pipe lines.

The provision of throttling screws or needle valves is a very valuable aid to speed control of any air cylinder. By its fluidity, compared with some other mediums, compressed air will move pistons with very great rapidity. This is sometimes an advantage where a sharp movement is necessary, but for other purposes a slower travel is desirable and restriction of the air flow is essential.

The adjustable needle valve should be placed between the operating valve and the cylinder if slow travel is only required in one direction and a check valve in parallel with the throttle will permit the rapid exhaust when the operation is reversed. A number of different refinements can be added to improve the advantages which air cylinders have to offer.

A small reducing valve should always be fitted if it is at all likely that variation in the working pressure will be needed and, in many cases of this type, a pressure gauge which will indicate the force being applied is a great help and enables the same conditions to be reproduced again at another time. As previously mentioned, an air line lubricator is desirable, and should always be fitted where the operator does not attend to the lubrication of the equipment as the initial cost will be repaid by the savings in upkeep and repairs.

Where the pipe lines are new, scale and small particles of swarf, jointing, etc., are likely to make their way through for some considerable time, and many engineers find it desirable to fit strainers at suitable points to prevent damage to the cylinders and valves. It should be noted that where reducing valves or throttling devices are employed the use of strainers is practically unavoidable as otherwise trouble will undoubtedly result. A choked throttling valve will reveal itself by the reduced speed of travel, but if a particle of foreign matter gets into a reducing valve, excessive pressure might result and cause trouble. Even though a pressure gauge and strainer have been fitted for use in conjunction with the reducing valve, a small relief valve should also be fitted between the reducing valve and the cylinder as such a precaution will prevent damage due to excessive pressure.

"Handling time" has become a very important factor when considered in relation to modern high production machines, and the following is an example of a recent successful solution of the problem. The description only shows the use of specially air operated fixtures without attempting to enlarge on the design, but those interested will find very full details in "Production Engineering Jig and Tool Design" by E. J. H. Jones M.I.P.E. (Geo. Newnes).

The operations involved are the milling of the top, bottom, and two side faces of a cast iron, six-cylinder, engine block on an Archdale traversing head line milling machine. The cutter head, incorporating a 15 h.p. motor for rotating the cutter, is a self-contained unit traversed for 17 ft. along the bed of the machine by a lead screw. The bed of the machine forms a stationary table and on this are mounted four special fixtures designed and made by the Associated Equipment Co. Ltd.

The cycle of operations is so arranged that the first cut taken by the machine completes the machining of the cylinder block, the

second fixture in the sequence is the third machining operation, and so on until the first operation is carried out in the fourth fixture.

A 15 in. diameter inserted tooth cutter fitted with stellite blades runs at a cutting speed of 120 ft. per minute and a feed of 7½ ins. per minute. Fast traverse at a rate of 20 ft. per minute is provided between all cuts and is tripped in and out at the desired positions. At the end of the travel the cutter head is automatically withdrawn 1 in. and the fast return motion to the starting position is automatically engaged. The cycle of the machine thus provides for practically continuous production, and loading and unloading of each fixture proceeds while another component is being milled.

On completion of the machining of the block in the first fixture on the table, the valve is operated to release the clamp and raise the arm clear to enable the work to be hoisted clear and passed on to the boring machine. When the cutter has passed the second fixture this is unloaded and the block is immediately loaded into the first fixture ready for the return of the cutter head. As each fixture is unloaded the component is passed on to the next operation in this manner so that it will be seen that the combination of air operated fixtures and the air hoist has provided the necessary speed to cope with the rapidity of the cutting cycle.

Fixtures with built-in cylinders for milling or drilling are particularly interesting, but each one varies according to the operation that has to be carried out, and the ingenuity displayed by the designers to solve problems is too often concealed due to modesty. A more frequent publication of descriptions in the technical press would be of inestimable value to all who would benefit from such experience. The usual purpose of such cylinders is the clamping of the component in position and this can be accomplished by raising the work up to the jig plate or alternatively lowering the jig plate on to the component, or by simple clamps.

Another aspect of clamping is found in a special fixture for boring gudgeon pin holes on a Heald borematic. This is an application of a proprietary cylinder as a Herbert non-rotating cylinder is incorporated to clamp the trunnion back on to its seating after it has been positively located for boring the gudgeon pin hole. As the table carrying the fixture moves forward towards the boring heads, the air control lever, on the right hand side of the fixture, comes into contact with a fixed abutment on the machine bed and opens a valve to allow air to enter the cylinder, forcing back the piston. This actuates the piston rod, which is attached to a lever, pivoted in the glut, and pulls the trunnion of the work fixture back on to its seating. As the table withdraws from the boring heads, the process is reversed, air is released from the cylinder, the piston moves forward, causing the operating mechanism to force the trunnion from its seating ready to be rotated to its new position.

Another example of a Herbert air cylinder built in is used in connection with the special machine which has been designed to grind the three eccentric grooves in the face of the scroll of the Coventry concentric chuck. A master cam plate revolves in contact with a roller carried by a bracket on the machine and controls the oscillating motion of the headstock. The air cylinder keeps the cam in contact with the roller and does away with weights or springs. Air cylinders are extremely useful for this purpose as weights, with the wire cable or chain and the necessary pulleys, are very often a nuisance and springs are a problem, particularly if a considerable travel to the table is required. The pressure of the cam against the roller remains the same, whatever the position of the travel, as the air pressure remains constant so long as the mains pressure does not vary, but naturally spring loading increases as the movement of the table compresses it further.

This application is becoming increasingly popular as its value is realised and designers are now incorporating air cylinders in profiling machines of all types. They are used quite frequently on lathes for forming operations and keep the roller, which is carried on an extension of the cross slide, in contact with the form bar. For turning face cams on drums, such as those used for steering clutches on certain types of tanks, or for producing the waves which are provided for securing the copper driving band on some shells, the air cylinder is used to keep the roller on the saddle in contact with a master cam, thus producing the necessary oscillating movement of the saddle.

Another use of air cylinders for milling machines is in connection with a double-ended fixture mounted on a central pivot, which has to be turned through 180° in order to complete the machining of a large component. A fixture of this type is, of necessity, heavy, and when loaded with components, would tax the physical strength of any operator unless provision was made to raise it by means of a thrust race or rollers. In this case, the movement of an air valve control lever withdraws the locating plunger and raises the fixture on a thrust race so that it then becomes possible to rotate the fixture with one hand. A simple air cylinder, mounted at the end of the fixture, thus saves time as well as energy by the ingenious device which is representative of this type of application.

Tailstocks are now manufactured with air cylinders built in, having in mind both speed of operation and convenience. For turning work, which has the rear end centred, the movement of a foot operated valve feeds the centre up and at the same time allows the operator to use both hands to support or steady the work. A further advantage with the air operated tailstock spindle is the fact that expansion of the work, due to the heat produced during the removal of the metal, is allowed for automatically. With an ordinary tailstock

spindle the operator has to make the necessary allowances while the operation is in progress as otherwise the expansion might cause undue pressure on the centre with dire results. With the air operated type, the pressure remains constant during the whole length of the operation, even though the centre moves back with the increase in length of the work. Where the delicacy or fragile nature of the work requires a light pressure, especially if the tailstock is relatively heavy, air operation shows its value as a small reducing valve permits the adjustment of the centre pressure to suit the individual circumstances and this can be reproduced as often as desired.

A lathe fitted with both a pneumatic chuck cylinder and air operated loosehead or tailstock has many advantages, particularly for some specialised types of work. A Lang-Heinemann lathe is arranged for finish turning shells after they have been finished in the bore. The drive is made through an expanding mandrel operated by the rotating cylinder, while the rear end is supported by the air air operated tailstock. The driving power possible with this means can be gauged from the multi-tool layout.

A similar machine is tooled for cam shafts but in this case a special chuck is used to give great gripping power on a very small diameter. This chuck is an application of the principle used in the previous example but adapted for external gripping instead of internal driving. Here again the loosehead cylinder is operated by a foot control valve to facilitate loading.

Thin cylinders are always a problem to hold for machining, particularly where large numbers are required and high production rates must be considered. A Lang-Heinemann lathe has been arranged for the production of cylinder liners. These liners are very light in section and are mounted on a collet so that they can be machined without distortion.

The expanding collet at the fast head end is operated by the air cylinder on the headstock spindle and does the actual driving. The liner is supported at the other end by the spring collet which is an extension of the fast head collet and this is expanded by the operation of the air cylinder on the loosehead, this cylinder being also controlled by a foot-operated valve to facilitate loading.

A particularly interesting example of a Lang-Heinemann multicut lathe has been designed, in which the tailstock is arranged to move crossways on the base to facilitate loading. The air cylinder, which performs this operation, is mounted at the rear of the machine, forming part of the tailstock casting. The machine was specially arranged for the machining of cast iron Diesel pistons from 4½ in. diameter by 7½ in. long to 7½ in. diameter by 12½ in. long.

To ensure high production rates the machining is carried out in three operations and use is made of air operated mandrels as well as draw back attachments and the pneumatic chuck.

The air operated mandrel has three jaws in front which hold the piston as close as possible to the dome, thus ensuring a uniform thickness where required, while the three back jaws grip the piston near the open end and ensure uniform thickness of the skirt. The thickness of the metal on the crown of the piston is regulated by the length stop fixed to the outer end of the mandrel. The drive is taken by two case-hardened pins which come in contact with the gudgeon pin bosses. All jaws and stop pins are easily interchangeable so that two sizes of pistons can be machined with one mandrel.

A push-pull type of air cylinder on the headstock spindle operates the two sets of jaws by means of two pistons in the one cylinder. One piston pulls through a draw rod to operate the front jaws and the other pushes through a hollow push rod to operate the back jaws.

For the second operation the piston is held in special soft jaws in a pneumatically operated chuck to finish face the end of the skirt and turn the bore for location purposes for the third operation.

The third operation is carried out after the gudgeon pin hole has been bored, the piston being held in an air operated fixture. This fixture is fixed to the flanged spindle nose and the piston is drawn back on a centring spigot by the operation of the air cylinder.

Pneumatic Bar Feed for Automatic and Capstan Lathes.

The usual bar feeding devices are operated by a wire or chain, drawing the bar forward when required, but a pneumatic bar feeding device was developed by Continental manufacturers, and this is worthy of mention for the ingenious application.

The guide tube consists of a thick tube closed at the far end and is connected by means of a swivelling joint to a pedestal which can be used as an air receiver. Compressed air at about 30 lb. per square inch is admitted to the guide tube by means of a suitable valve and forces forward a small piston which feeds the bar up to the stop on the machine. The valve is then closed and the air remaining behind the piston is allowed to escape so there is no axial pressure on the end of the bar.

The bars are inserted into the guide tube from the operator's position, the tube swivelling outwards on a supporting bracket. For automatic work the valve is operated by the feed cam on the machine and the control is provided so that the self-acting mechanism is automatically disengaged when the end of the bar is reached. As the length of the bar is reduced, the valve is still only opened for the same length of time and consequently the air pressure is reduced as the air space increases with the amount of bar used ; however, the bar has lost weight and the resistance to the stroke of the piston is consequently smaller so that there is no difficulty with feeding.

To cater for varying sizes of bars an adjustable valve is provided for altering the pressure to suit the conditions prevailing. This

device is practically silent in operation and very economical in use as the quantity of compressed air required is very small.

Cylinder Control Valves for Fixtures and Machine Tools.

Control valves for the operation of single or double acting cylinders on all types of fixtures and machines should be carefully chosen to fill the requirements of the particlar problem being dealt with. The choice would normally lay between the piston valve, taper plug, or poppet valve types, and the relative advantages and disadvantages of each should be considered.

The piston valve type is simple to produce, if reasonable machine facilities are available and care is taken in lapping the valve into the body, but the clearances must be small if serious leakage is not to take place, and wear, when in use, can easily destroy the original accuracy in a relatively short time. There is, of course, no method of making adjustment for this wear so the valve has to be plated or scrapped and the body bored out larger, as otherwise the loss due to leakage may become considerable. As described in another section, the loss of 10 cu. ft. per minute in a fifty-hour week would cost £10 per year, and although the loss from a faulty valve would normally never reach this figure the losses are always worthy of consideration. The chief reason for choosing a piston type valve is its convenience where multiple porting is necessary or where the operation of the valve by a linear movement is desirable. As long as a very compact valve is not necessary, the piston valve has an advantage over the taper plug valve, when in good condition, because a longer area can be arranged between ports, thus helping to prevent loss of air or short circuiting from one port to another. It is most important, however, to remember that this does only hold good when the valve is in very good condition, and that the piston valve would only be chosen for the exceptional case and, for preference, where it is not in continual operation.

When designing a piston valve, the provision of a few light grooves round the diameter between the ports will help to reduce leakage in a rather surprising way, as the loss of air is less under these circumstances than if the piston was quite plain. If the valve is required to move freely, a balanced pressure on the side of the piston is necessary; that is to say, it would not do to provide only one inlet hole or a port on one side as the air pressure would force the valve over the opposite side and cause considerable resistance to movement due to friction. It is sometimes possible to provide a cut away portion of the valve at the air inlet so that the valve is never a close fit in the bore at this point, otherwise the body should be made in such a manner that the air pressure can enter on either side of valve or all round it.

Whatever type of valve, is used it is vitally important to make provision against the dangers of air leaking across a valve face into another port. Care should be taken in designing or choosing multi ported valves to see that the exhausted end of a cylinder is always open to the atmosphere, whatever the position of the valve, apart from the one position at which the exhaust is closed and compressed air admitted. If this precaution is taken, trouble will never be experienced with what is known as creeping, due to valve leakage into a single acting cylinder, or by leakage, from the valve or past the piston in a double acting cylinder, building up and balancing the pressure on the working side.

In spite of the difficulties of producing a taper plug cock accurately and keeping it working smoothly and easily without a fair amount of attention, they are very popular whether used separately or built in as part of a unit, and quite complicated arrangements of ports can be arranged by the exercise of a little ingenuity. If this type of valve is used, a little attention should be given to them occasionally to make sure that they are working easily but without air leaks. They have to withstand a considerable amount of ill treatment by some operators who seem to have no compunction about using a hammer or heavy object to make adjustments. Their method of tightening a leaky valve is to hit it on top and a blow underneath is used to ease a tight valve, but, needless to say, this practice is rarely done openly without considerable discouragement on the part of the management. Certain types of valves have provision for lubrication but it is not difficult to provide it in the valves designed for use with special fixtures, particularly if lubrication nipples of the same type and size as those provided with the machine tool are used. Where the air is oily or if the lubricator can be fitted on the supply side of the valve, there is usually no trouble about lubrication and the only causes of a tight or sticky valve, are the use of the wrong taper or poor manufacture. The washer, interposed between the securing nut and the body, should always be made so that it rotates with the valve as otherwise it will assist the nut to tighten up or slack off, and, although this is a simple point, it is sometimes overlooked. A substantial stop should be provided at each end of the travel of the valve as this will greatly assist the operator in speed because no thought need be given to the position of the valve, while, if an intermediate position is necessary, a detent will help very considerably.

An ingenious taper plug cock, first placed on the market many years ago, avoided all the difficulties connected with the use of nuts and washers and adjustments by the use of a spring. The taper was inverted ; that is to say, the smaller diameter was nearest the handle instead of the larger, as in the conventional type ; and the plug was pressed into the body by means of a short, stout spring

housed in a cap screwed onto the body. The valve could be eased by hand pressure on top but it would always return home and any wear in use would be immediately taken up by the pressure of the spring.

The poppet valve type is by far the best for most purposes of control and has the advantage that wear is automatically taken up, thus avoiding wasteful leakage and a considerable amount of maintenance. There is also possible a greater delicacy of control and speed of operation, when compared with the taper plug cock with its semi rotary motion, as the vertical movement of the handle can be much more easily controlled, whether by the hand or foot. Valves operated on this principle can be obtained for hand, foot, mechanical or electrical control in various forms and types so that it is possible to find one that will fill any particular requirement.

For some purposes, a foot operated valve has many advantages and the developments of this type of control have proved to be very valuable. The operator is able to secure or release work or perform any operation while the hands are both free to steady or support the work or be employed in any way as desired. Pneumatic chucks, vices, fixtures, tail stocks and cylinders are now commonly controlled in this way and the method has become deservedly popular now that this type has become available. It is, of course, possible to use the taper plug cock for foot operation but it invariably means a conversion or a specially constructed valve whereas the poppet type is available as a commercial type.

Poppet valves can be obtained in the locking type or the non-locking type and each has its particular use. Where it is necessary to maintain pressure during the whole or part of an operating cycle the locking type is used, as the valve remains exactly as placed until returned at the will of the operator. The non locking type is different in so far as releasing the lever immediately cuts off the air supply and opens the end of the cylinder to exhaust. This is useful for many operations, such as feeding operations where the duration of the pressure is important, as it enables inching to be easily and rapidly carried out. It is also valuable where the operator must keep the hands away from the machine as two of these valves in series provides a very simple and easily arranged safety device.

Another very useful type is designed with a single treadle for foot operation, where each stroke with the foot reverses the valve and locks it in position, thus giving a simple and speedy operation with the minimum of stroke.

All valves should be mounted as close to the operating cylinders as possible in order to avoid the loss of air which is in the pipes when exhausting the cylinder but there are occasions when it is necessary to have the control point at some considerable distance away.

In this case it is desirable to consider the adoption of a remote control device operated by the air supply or by electrical means.

It is sometimes an advantage to use the same supply of air which operates the cylinders and this is easily done by means of a relay device. It has, however, the disadvantage that it calls for a design using piston valves but quite small bore pipes can be employed up to the operating point. A very small movement of the control valve, with the minimum of effort, is all that is required to control even very large cylinders at a considerable distance while the losses in the pipe line due to friction and exhausting are kept to a minimum. Where the cylinders are only required to work at comparatively infrequent intervals the results are very satisfactory and no other power medium is required. Particular examples are the control of extra high tension switchgear from distant points and the operation of very heavy pneumatic clutches. Where electricity at a convenient voltage is available, remote control employing this medium is possible by the use of solenoid operated valves.

This type of valve has other uses besides remote control and has proved to be very valuable as a solution for many problems. The operation of air cylinders controlled by photo electric cells, thermostats, limit switches and other electrical methods involving make and break devices has opened up a very wide field for ingenuity. The operation of doors by such control and its use in connection with press tools and various fixtures is mentioned elsewhere but there are many other possibilities open for investigation.

One interesting example is the magazine gate for feeding work into a centreless grinder or similar machine. The feeding can be arranged to operate by means of a pusher operating in the bottom of the magazine or by means of a gate which is shuttled to and fro, either method being actuated by a small air cylinder. The pusher can be throttled down by means of a suitable needle valve so that the feed is regulated to the correct rate and makes a very simple unit. The magazine gate can be used in conjunction with a pusher or, if more convenient, a small conveyor belt to feed the work forward. In either case the release of the work to ensure continuous feeding is controlled by a solenoid operated valve which is operated by an electric contact or by means of a photo electric cell. This gives continuous feeding with the minimum of interval and calls for no attention from the operator except for the occasional refilling of the magazine.

The recent development of " micro " switches, which need only a very light force and a movement of about a thousandth part of an inch to operate them when used in conjunction with electrically operated valves, make many new devices possible. They are now being employed to control clamping devices so that the act of the operator placing the work in position automatically opens the air

valve and admits air to the clamping cylinder. They are also used for the purpose of interlocking as a satety device to prevent an air cylinder operating until a moving un t has reached ts proper position. Such an arrangement would be seen in an operation where two cylinders have to work in proper sequence but where it is important that the second should not operate until the first has travelled the correct distance. The first cylinder could be controlled by any suitable means but the second cylinder would be controlled by a solenoid operated valve. This would be automatically operated by the micro switch at the correct moment and in consequence would be independent of the operator once the sequence had been started. Where the circumstances warrant it, an arrangement of this type could be so devised that the whole control would be started or reversed from push button stations with limit switches and various contacts for time and temperature control to provide the automatic features. There are quite a number of operations where this could be employed to give a considerable saving of both time and energy.

The spring loaded poppet type valves as used on power presses for work ejection and for various purposes, either hand or foot controlled, are referred to in other sections but one interesting use is seen on assembly benches where light work is carried out. Where the complete assembly does not weigh more than an ounce or two, an air jet is arranged at a suitable position to blow the work into a chute or tray on completion of the operation. A push button valve fixed on the bench or a foot operated valve enables the operator to clear the assembly position or fixture without picking up the detail. The foot control enables the operator to have both hands free to pick up further components while the assembly is being discharged.

Haskins Air Controlled Tapping Machines

Although tapping machines have been used in production for many years, the use of air control only came into being about 1936, and at first consisted of an air cylinder, foot operated valve and regulator and the necessary hose connections. This attachment could be fitted to machines without alterations and rapidly proved its value. The natural step was then towards a machine with this device built in, which finally resulted in the develoment of a machine where all features are an integral part of the construction.

The tapping mechanism is housed in a special head and is driven from a multi step " V " belt pulley through a splined shaft, power being supplied from a suitable electric motor. The tapping operation is controlled by an automatic air valve which supplies the air for both the tapping and reversing strokes of the tapping head. The control of the speed of both tapping and reversing is independent

of the operator and, when once set, will repeat the cycle as often as desired by a mere pressure of the foot operated valve.

Compressed air does away with the variation that is always present, even with the best operator, as the control will supply a carefully regulated pressure, adjustable to suit each set of circumstances. The reduction in physical effort is also very important as the operator only has to feed in the work and apply a light pressure to the foot pedal.

Another point of the greatest importance lies in the fact that it is generally recognised that tap breakage, wear and dulling of the tap takes place during the reversing operation, owing to pressure on the thread angle. In consequence it is necessary to ensure that the pressure controlling the reversing should be even more accurately regulated than when cutting the threads and here the air control has the greatest advantage over the judgement of the operator.

The tapping head consists of a housing for the clutch, reverse gear and tap spindle supported by two pistons in the air cylinders. The upper clutch shell, which is the drive for tapping, is driven by a splined shaft from the pulley shaft while a gear cut on its circumference drives the reverse gear wheel which is an integral part of the lower clutch shell.

The clutch has a hardened steel hub which is pinned to the tap spindle and this whole unit is extremely light in weight to ensure sensitivity. A small coil spring counter balances the weight and, when idling, the clutch is balanced between the two shells. The hardened and ground tap spindle has a very light collet nut and collet which grips the tap on the shank while the drive is made through the square end. The slightest touch on the tap spindle in either direction brings the clutch in contact with the appropriate shell supplying driving or reversing power to the tap.

The operation of the foot pedal allows air to be admitted to the top of the air cylinders through the medium of the automatic valve and this feeds the tap head down to the work. The touch of the tap on the work engages the clutch and threading commences. Since the tap is revolving at a certain speed and consequently can only generate its lead accordingly, the speed of feed of this downward travel is regulated to suit the pitch of the thread, and the r.p.m. of the spindle which has been set to suit the material being tapped. The adjustment of this pressure must be sensitive to permit the tapping of blind holes but positive enough to avoid clutch slipping. The lower portion of the cylinder is always under balanced pressure which is very carefully regulated under the control of a carefully throttled exhaust. This avoids any pressure of the tap on the thread angle when reversing while the speed of the tap is doubled to save time. Even though the foot is kept on the control

pedal and the cycle recommences automatically there is an adjustment on the automatic valve which delays the recommencement of the stroke sufficiently long to allow for the unloading and reloading of the fixture. The depth of the tapped holes can be regulated by an adjustable stop thus ensuring accuracy in blind holes and the elimination of excess stroke in through holes.

The automatic air valve is designed to also supply air at the appropriate moment to operate dial feeds, hopper feeds and ejector type fixtures. The tap can be lubricated by a motor-driven pump which gives a continuous flow of oil but sometimes it is more convenient to have a single shot of oil and this is accomplished by an air operated plunger pump which is also controlled by the automatic valve. The air consumption is extremely small, a typical example being the tapping of a standard steel hexagon nut $\frac{1}{2}$ ins. diameter 20 threads per inch requiring only 4.6 cub. ft of air per hour at 30 pounds pressure, with a production of 1,500 pieces per hour.

In connection with this machine, use has been made of the latest developements of "Micro" switches which, being operated by a very light pressure and a small movement, are consequently very sensitive. Under normal circumstamces it is necessary to insert the work into a fixture and then press the foot control valve to start the automatic cycle. An electrically operated fixture has been designed which eliminates the foot pedal control and controls the operation of the machine by the insertion of the work into the fixture. As the part is placed into its correct position for tapping, a plunger at the rear of the fixture trips a micro switch, thereby setting the machine in operation. The switch, which is mounted in the base of the fixture, closes the circuit to a solenoid valve which then allows the air to enter the automatic valve. The tapping operation starts automatically and continues through the cycle until the operation is completed; the work is then ejected by a spring and the machine is ready for reloading. The base of the fixture can be utilized for any job as the work is located by a small hardened steel fixture which is interchangeable on the base.

Where the work has to be held in a vice for a tapping operation, it is an advantage to utilise the operation of the machine to secure the work. This is achieved very simply by arranging that the downward movement of the tapping head operates a micro switch controlling a solenoid valve. This in turn admits air to an air vice or other air operated fixture so that the work is firmly held without any attention on the part of the operator, except for the loading. Both hands are free to handle the work and, on placing the work in position, it is only necessary to press the foot control to ensure that it is automatically held and tapped.

These methods, which lend themselves to a wide variety of

different arrangements, give great savings in time and increases in production, while they have many potentialties for ingenious designers.

Compressed in the Inspection Department

Compressed air is not often supplied to the Inspection Department but it has quite a number of uses which make the extension of the shop system worth while. Quite a lot of manufactured details are now tested for leaks by immersing in a tank of water while under air pressure. It should be realised that it is vitally important to be absolutely certain that the article will stand up to the air pressure before any air is allowed into the vessel or container, as otherwise very serious damage may be caused with possible danger to personnel. Unless it is well established that the work being tested will safely withstand at least double the air pressure to be used, a hydraulic test should be applied first. The importance of this should always be impressed on everyone using compressed air as serious accidents have happened through the neglect of this very necessary precaution. When minute leaks have to be discovered, the air pressure test under water cannot be bettered as the air is infinitely more searching and self revealing than a hydraulic water test. Air for this purpose is sometimes used at very high pressures, according to the circumstances, and pressures from 600 to 1,000 lbs. per square inch are commonly supplied by small compressers which are specially installed for the purpose. It is sometimes advisable to provide heated water in the tank in which the work is immersed as the slight expansion may reveal defects that would otherwise have remained hidden.

In connection with hydraulic pressure testing, air serves another purpose in which it is the source of power to drive a hydraulic pump. Where a small supply of high pressure water is required for hydraulic testing, an air operated pump enables any predetermined pressure to be obtained without any physical effort, thus allowing female labour to be employed on certain classes of testing, as the movement of a simple valve is all that is necessary instead of the laborious effort required for a hand operated pump. The air is used at the pressure of the shop mains and is supplied to a double acting cylinder. The movement of the piston is imparted to the water cylinder containing a fixed ram and as the air piston is of a larger area than the ram a higher pressure is produced in the water cylinder. The pump operates quite automatically, reversing at the end of each stroke, and builds up pressure until the total load in the water cylinder is equal to the power which can be provided by the air cylinder. When this is equal, the ram comes to rest but it restarts again as soon as the balance is disturbed by a reduction in the water pressure. The rams are designed to give

pressures up to 750 pounds per square inch by means of the low pressure pump and up to 4,000 lbs. per square inch by means of the high pressure pump, both being operated by air at 60 pounds per square inch. The pressure of the water is determined by the pressure of the air supplied to the air cylinder and this can be varied by means of an adjustable reducing valve. The setting of this valve determines the maximum pressure of the water applied to the work and the valve is regulated to suit the requirements of each job. The air is distributed to the top or bottom of the air cylinder by a valve which is operated at the end of each stroke by the movement of the water cylinder attached to the air piston. The water ram is a fixture to the top plate and the water supplied to the cylinder is led down through its centre. Mounted above the ram are the inlet and outlet non return valves, the inlet being connected to any low pressure water supply while the water under pressure is delivered from the outlet valve through a suitable pipe and connection. Where a permanent test bench is provided a three way control valve can be employed. The article to be tested can be filled with water from the mains by means of this valve, thereby saving time as no separate operation is needed, and also saving air as this is only used for the small amount of water that is required to complete the pressure test. The pressure gauge for the hydraulic test can be mounted at any convenient point between the pump and the test bench.

Jets of air for cleaning are as useful in the Inspection Department, as anywhere else in the works, and this air can be supplied from blow guns on flexible hoses or from fixed jets at suitable points. The later method is extremely useful as the air can be controlled by a foot operated valve, or even a push button valve mounted on the bench, as the air can then be used for cleaning operations at the same time leaving the hands free to handle work and gauges.

Compressed air operated fixtures are as valuable for inspecting and checking as they are for machining operations and this comparatively new development is receiving a considerable amount of attention where it is necessary to inspect sufficient quantities of a detail to warrant a fixture of this type, such as an air operated checking fixture for main bearings for one type of motor car engine, comprised of steel shells lined with white metal and machined all over. The bearing rests in a formed block, one joint face being positioned by the stop piece on the left. The operation of the valve on the front of the machine admits air to the cylinder on the right. This pulls the beam down against a pressure of a coil spring and the movement continues until a stop piece comes into contact with the second joint face of the bearing and presses it into the recess block. The dial gauge mounted

on the beam measures the position of the beam in relation to the pillar mounted on the base and in consequence shows any variation in the dimension from the ground outer surface of the work to the joint faces. A safety pillar, is provided to guard the dial gauge from damage if the fixture is operated when unloaded, while a safety shield, mounted on the valve lever, prevents the fixture from being operated if the Inspector's hand is likely to be trapped.

Compressed Air in the Press Shop

Compressed air has several uses in the Press Shop but probably the most common one is the ejection of blanked or formed work from the dies. This has proved to be very valuable and, in many firms, all the presses are fitted with suitable equipment for this purpose from the largest to the smallest. It helps to ensure the safety of the operator but, even more important, are the savings obtained by the increase in output. These are always appreciable, as the operator only has to insert the blank when forming or shaving and the die is cleared and cleaned automatically, so that improvements in output up to 50 per cent, of the original output have been obtained.

A timed blast of air is arranged so that the article or detail is ejected into a chute while the ram is rising. A poppet type valve is mounted in a suitable position on the press so that the plunger is depressed by a cam or a trip lever at the correct moment and for a suitable length of time. The cam can be of the solid type, either disc or segment, or it can be of the adjustable type, while the valve can be opened either by direct pressure on the plunger or through the medium of a lever. In some cases it is more convenient to make use of the upward movement of the slide but it is usually necessary to make some provision for a trip lever so that the jet of air is only released when the ram is rising. A plain projection on the ram would operate the valve on both the up and down strokes and the work might be ejected just as the tool was closing, so this precaution is very necessary and can be easily arranged in a very simple manner by using a small hinged lever with a stop pin underneath it.

The valve used can be one of the several types designed and placed on the market for this purpose or it can be manufactured quite easily but the poppet type valve should always be used, when possible, as the maintenance required to keep it leak proof and in good working order is less than with other types. Valves can be purchased which use the standardised parts produced for blow guns and, if this type is used, the number of spares required to be held are considerably reduced.

The air from the valve can be directed on to the work by a copper pipe connected direct to the valve but, under most circumstances, it will be better to take the air to a small manifold, mounted at a

suitable position on the bed, the press sides or the bottom die, a connection to the valve being made with flexible tubing or small pipe. The manifold can have two or more connections, any of which can be blanked off with a cap when not required, so that a combination of air jets can be used to the best advantage when necessary. With some types of tools, the provision of locations or other reasons may make it difficult for the air jet to remove the part by blast alone, and in this case an air connection is provided to the die itself. Holes are drilled in the die so that the air lifts the work and the jet can, then blow it to the chute at the rear of the tool. In cases of this type, the manifold is very useful as the extra connection is easily made when required. For shaving operations, a combination of jets will remove the work and clear the die ready for the insertion of the next detail in the minimum of time and without thought or care on the part of the operator. The amount of air used is very small and, although the installation is both simple and cheap, the scope is so wide that this use of compressed air has become very popular.

Spray guns, used for handling lubricants of various grades, are well known for their various applications in garages and service stations but they are also employed for lubricating strip steel as it is roll fed into the dies, in place of the usual methods. The spray can be adjusted on some types, according to the amount of coating required, and the type of lubricant used. In some cases, the same valve that controls the ejection of the work is utilised to supply sufficient air for this operation but, in other cases, a continuous supply may be used or the spray gun may be used by hand as required.

One of the most important factors to be considered in the process of drawing various shaped parts from sheet is the pressure that should be applied to the flange. This pressure should be just sufficient to keep the metal from wrinkling and for shallow cups can be applied by means of springs or rubber discs. For deeper drawing operations, however, this is not too satisfactory owing to the increase in pressure as the draw proceeds.

Pneumatic or possibly air hydraulic die cushions give valuable assistance for the solution of this problem and the consumption of air is negligible. A cylinder and piston are mounted under the bed of the press in a suitable manner so that one or the other moves against the pressure of the air when pressure is applied on the bottom die. The air pressure returns the die section, after the operation is complete, in the same way as a spring but with the added advantage that at any point of the travel, the load remains the same as at the beginning of the operation. A small air reservoir and a

reducing valve is the only extra equipment needed ; the later permitting suitable adjustments to be made for each operation to ensure the correct drawing pressure in spite of the fact that the air is drawn from the main shop supplies. The air-hydraulic system uses oil in the cylinder supplied from a reservoir, and with air on the surface to provide the correct pressure through the medium of a reducing valve.

Many presses are now fitted with air cushions and large presses are often supplied with several, each operating on its own cushion plate. If they are not required for drawing operations these presses can be used in connection with the return type of blanking dies which, although more expensive to construct, are used in cases where the drop through types are impracticable. It is stated that this type of die is slower in operation because the blank must be removed from the die at each press stroke but, if careful arrangements for ejection are made, very good results can be obtained, comparable with the drop through type of die. A positive knockout is desirable as then the blank moves upwards with the die until it is ejected. At this point the provision of a blast or jet of air, coincident in timing with the knockout, will blow the blank to the rear of the press. With this type of die and with air operated stock stripper there are no springs and one of the potential causes of trouble is removed.

On certain classes of work it is an advantage to withdraw the bottom half of the tool to the front of the press bed for loading, as it is much easier for the operator to put the work in position accurately by hand than to attempt to do so with tweezers or a push rod. These slides, accurately guided for position, are extremely valuable in use but they have the one failing that a considerable effort on the part of the operator is necessary for the maintenance of output.

An ingenious arrangement, designed and patented by Standard Telephones and Cables, Limited, has been devised to increase the speed of output and, at the same time, reduce the effort to the movement of a very small lever controlling an air valve. The slide is moved by a small air cylinder, mounted at the back of the press, and operating through the medium of a yoke attached to the piston rod and connected to the slide by means of side rods. The movement of the slide is interlocked with the press so that when the foot pedal operating the clutch is depressed the slide cannot be moved. The air cylinder, in spite of its small size, moves the slide rapidly and easily, with a very small consumption of air and a shock absorber is incorporated so that the slide goes home without jarring the work. Air is admitted from the shop mains to either end of the

cylinder, as required, by means of a valve mounted on the front of the slide and moving with it. The valve is controlled by a small lever, conveniently placed so that the operator can easily touch it to draw it forward when the slide has to move out for loading and push it backwards when the slide has to return.

Air Hydraulic Accumulators for Hydraulically Operated Machine Tools

Hydraulically operated movements on machine tools are now common but, almost without exception, each machine is fitted with an individual pump to supply the motive power. Where a number of machines, such as shell turning lathes, are installed it is possible to employ a central plant which will feed each machine with economy in maintenance and efficiency. The hydraulic power is supplied by a specially designed pump but delivery is made through the medium of air hydraulic accumulators. The accumulator cylinder is normally about half full of oil while the air space above is maintained at the working pressure. The oil, being pumped in for the first time, compresses the air to a certain extent but futher air must be added by means of a suitable compressor to maintain the oil at the proper level. When the pump is able to supply more oil than is being used, the air is further compressed until a point is reached at which the motor is automatically switched off until the demand has lowered the level again, thus utilising the energy stored in the air and no by pass relief valves are needed to disperse the unwanted power supplied by the motor.

In one particular installation, the pressure on the pistons feeding the saddle towards the headstock and operating the cross traverse is supplied at 500 lbs. per square inch but the return motion is effected by a pressure of 100 lbs. per square inch on the opposite side of the piston. The oil is maintained at this lower pressure during the whole of the working period but is overcome by the higher pressure used for the cutting feed. The movement of the tool is controlled by admitting oil at the higher pressure or by releasing it as required. The oil for the lower pressure is used in a closed system and consequently a pump is not required as the oil is returned to the reservoir at the working pressure and only very slight leakages have to be made up every few days by the addition of a little more compressed air. The oil exhausted from the higher pressure cylinder is returned to a tank and is drawn from this by hydraulic pump which delivers it to a high pressure accumalator. As already described, the upper part of the accumulator is occupied by air under pressure while the oil level is ingeniously controlled by a system of photo electric cells. The oil level can be seen by means

of a gauge and the photo electric cells are mounted in such a way that the alteration in level interrupts beams of light. At the lower level the light falling on the cell operates a relay which starts the pump to supply further oil to replace that used. Interruption of the light at the higher level has a reverse effect and the pump is switched off until such time as the level falls again.

Oil Supplies by Pressure Feed

A comparatively new use for compressed air is the distribution of lubricating and other oils, and is one in which the garages and service stations have quickly adopted industrial ideas with great enthusiasm.

Oil is received in drums or other containers and can be rapidly transferred to storage tanks by connecting a compressed air hose to a suitable connection on the drum or to an adaptor screwed into the bung hole. A pipe goes to the bottom of the drum and when the air is turned on, the oil is forced up through this pipe into the storage tank. This method eliminates the necessity for using a crane or skids for lifting the barrels on top of the storage tanks or the alternative method of laborious hand pumping. Naturally, in using this method, precautions are taken to ensure that too high a pressure is not applied to a drum and if a reducing valve is not used a pressure gauge or small safety valve should be inserted between the control valve and the drum.

This method can also be adopted for the distribution of oil at suitable points in the stores or works with the added advantage that the oils are stored in underground storage tanks, thus saving valuable space and offering a considerable measure of protection from fire and damage. Instead of using individual pumps for each grade of oil, air pressure is maintained in the tanks and a pipe is taken from the base of each container to a central point where it is instantly available, as readily as water would be drawn from a tap. A stop valve is provided in each separate air line so that any tank can be shut for refilling when necessary.

In addition to these valves, another valve should be fitted in the main air line to enable the whole group to be shut off and a valve should be fitted which will allow the air pressure to be released from the tanks if there is any likelihood of damage to the reservoirs or oil pipe lines due to fires or enemy action. The oil pipe lines lines can be grouped so that the oil is delivered at any position, and meters and visible flow devices can be fitted as refinements if required. It is however, necessary to point out that the adoption of this particular system turns the storage tank into an air receiver which is governed by the Factory Act, (1937).

When it is desired to make use of a normal oil tank which can be installed below ground level with all the attendant advantages, an air operated pump can be installed and the pressure supply will be obtained in the most convenient position. A pump of this type is provided for each tank and operated automatically without without any attention. A suction connection to the oil tank, a delivery pipe and an air connection are all that is needed to provide all the advantages of the pressure feed without the disadvantage of a tank under pressure. When air is admitted to the pump, it operates until the oil in the delivery pipe reaches a predetermined pressure when the air pressure is balanced and no further air is taken. When oil is drawn off, at the opening of the oil control valve, the automatic air valve comes into operation and a supply of oil is fed all the time that it is required. As the pump only operates when oil is being drawn off the consumption of air is accordingly very small.

Lubrication of Overhead Conveyors.

Conveyors can present a very definite lubrication problem of their own, particularly with overhead trolley types which are passing through washing plant or hot ovens where the oil or grease may be entirely removed or caked up and it then becomes necessary to make frequent applications of oil otherwise seizure is likly to cause serious hold up in production due to the whole plant being stopped. On the other hand the amount of oil must be carefully regulated as the cure may present fresh problems due to the oil dropping on to the work or various parts of the plant. A very efficient solution of the problem has been adapted in some works making use of compressed air in a very simple manner which can be adopted to any type of installation.

The principle involved is a very familiar one in which a flow of air can be arranged to carry with it a definite quantity of oil which can be adjusted to suit variable requirements. A small bracket carrying the air line lubricator and control valve is fixed at a suitable point where the valve can be operated by a lever which is tripped by each trolley wheel as it passes. The air passing through the lubricator is reduced to suitable pressure by a small reducing valve which is adjusted to meet local requirements.

The length of time which the valve is open can be adjusted by a suitable variation of the linkage between the trip lever and the valve and thus the air passing through the lubricator picks up the required quantity of oil which is blown into the bearings in the form of mist.

Air Operated Presses

Air operated presses have been designed for many purposes besides riveting and have the advantage of speed combined with economy and silence. Their use in the machine shop includes push broaching machines, mandrel and bush presses and marking presses. All presses show considerable advantages if a reducing valve is used in conjunction with them as this valuable accessory provides very accurate control of the working pressure which can be varied to suit different circumstances.

For push broaching, this use of a predetermined pressure which is independent of fluctuations of pressure in the air lines, enables the most delicate broach to be used with the assurance that it is impossible to break it. In the special machine designed for this purpose the main air piston is fitted with a rod on the top carrying an auxiliary piston in an oil cylinder and by this means the machine is given all the qualities of a hydraulic machine. On the down stroke the oil is circulated through a control valve which can be opened or closed to any required degree while the air entering at a faster rate then the oil can flow ensures a constant pressure on the air piston. The speed of the piston can be instantly varied by means of the control lever but when the broach has passed through the work, the press does not "run away" as would be the case with a plain air cylinder. The return stroke is always made at a constant quick speed irrespective of the control setting for the working stroke.

The assembly of ball bearings, bushes and valve guides and shafts in pinions calls for considerable discrimination on the part of the operator as otherwise the assembly is too loose, with its attendant troubles, or too tight causing distortion which needs further work for correction. To-day when the best use of man hours is imperative and dilution is becoming increasingly necessary, this problem can assume major proportions, calling for extra inspection and producing more scrap. A press, now on the market, is fitted with two reducing valves which have the effect of giving the machine automatic "GO" and "NO GO" inspection and ensures assembly between known pressures. The first reducing valve is set to a pressure, which would give assembly with the components too loose in fit while the second valve is set just sufficiently higher that it refuses to assemble components which are too tight. Thus if the assembly goes together on the low pressure it is rejected, but if it does not go home until the high pressure is applied, the job is right.

All air operated presses can be made as safe against the fool-

hardiness of careless operators as a mechanical press so that safety guards, interlocked with foot control-or duplex handles can be fitted and both hands must be used before any movement can be obtained.

Air Operated Doors

Heating of workshops, where constant traffic of power trucks is passing in and out, can be a very great problem and in addition the driver spends time opening and closing the doors which should be employed more usefully in speeding up transportation. Both sliding and hinged doors can be air operated and show a considerable economy in working by the saving of valuable time and also petrol where this form of power is used. The cylinders can be operated by hand control, trip valves or by means of electrically operated valves controlled by a floor switch or a photo cell. Naturally the latter two methods are the best as the adjustments can be set so that the doors open in time for the fastest truck and remain open just long enough for the slowest method of transport but even then the length of time the doors remain open to admit cold air is considerably reduced while the driver does not even have to slow up instead of starting and stopping twice and opening and closing doors.

A photo electric cell is installed on a wall or inside the post a few feet in front of the door and a beam of light is projected across the path on to it. When a person or object intersects the beam, the sudden variation in light intensity operates the relay, which in turn operates a solenoid valve in the compressed air main. The air is admitted to the cylinder through a suitable throttle valve which controls the speed of opening and the piston is connected to the doors through the medium of suitable linkwork. At the end of the operating stroke a cam closes the air valve and the door is then closed by means of springs or by air is a double acting cylinder is used, the speed of closing being adjusted to suit the local conditions.

Raising Water by Compressed Air

The use of compressed air for raising water from wells has been in commersial use for many years. The method was invented in the 18th. contury and actually used in Germany at that time but it really only came into general use late in the 19th, century. The principle governing the air lift is simply that the intermixing of air with the water in the discharge pipe reduces the density so that the head of water outside the pipe can support a greater head of the mixture inside and this rises in the pipe and overflows at the top into the tank.

In its simplest form the air lift pump consists of two pipes which pass well down below the surface of the water. The larger pipe is open at both ends to form the water discharge pipe while compressed air is forced down through the smaller pipe and enters the larger one at the bottom. The efficiency of the pump is governed by several variable factors such as the sizes of the pipe to be used and the "submergence" or depth to which the pipes must be immersed in the water for a given lift, but the specialists in this type of installation have a very wide experience on which they base their design to suit the conditions that are met in each circumstance.

There are many advantages in this method of pumping as there are no moving parts in contact with the water and as the air compressor is installed on the surface it can easily be attended to so that sudden breakdowns are less probable and adjustments and maintenance can be readily carried out when required. Even when water is sandy or gritty or contains acid or chemicals, the maintenance is very simple as this foreign matter does not come into contact with any parts except the pipe. The expansion of the air absorbs a certain amount of heat from the water and this is a great advantages where cool water is required for such purposes as condensing. The aeration of the water is no disadvantage as it improves the quality of the water and is considered to render it more susceptable to subsequent treatment for hardness and the separation of chemicals in solution.

In actual practice a foot piece or ejector is mounted at the bottom of the rising main and this consists of an arrangement to mix the air with the water, manufactured in various forms according to the ideas of the maker. For efficient working, the designers endeavour to submerge the pipe about 50 per cent of the total length of the pipe up to the point to which the water is discharged. This depth is based on the level of the water when the pump is delivering its maximum capacity, but it must be remembered that this working water level is lower than the standing water level, which is reached when no water has been pumped for a period of time. This difference in level is due to the fact that normally water is percolating through the strata and in consequence it is impossible to maintain the level due to restriction so it continues to fall until the discharge is balanced by the rate of inflow. This working or pumping water level is the most important point to be considered and affects the design of the whole plant so it is usally determined by experiments, although sometimes it can be computed in advance from a knowledge of local wells. As the water level is higher when the pump is first put into operation, it will be realised that greater

pressure is necessary to overcome the greater head of water, but once the flow commences and the water level drops, the working pressure of the air is reduced in proportion.

In the early years of its develpment the air lift system had a reputation for inefficiency, but by careful study of all the varied aspects and other inter-relationship, water pumping engineers have been successful in raising the efficiency to about 40 per cent. Although it is not claimed that air lift pumping is the most efficient, there are so many advantages, that when all costs including upkeep are taken into consideration it can easily prove to be cheaper in the long run. In the case of the deep well pump of good design, the actual power expended in raising water will probably be a little less than in the case of an air lift, but overhaul and repairs would be much more expensive owing to the working parts being inacessible, due to their position in the well. The popularity of this system can be best judged from the very large number of installations that are now working in all parts of the world.

Water or suds supply to a works is often maintained by an overhead tank which is filled by a pump running at intervals when the level falls. When it is not convenient to have a storage tank at a high enough level to provide sufficient pressure, compressed air can be satisfactorily utilized to provide the artificial head by means of air pressure on the surface of the liquid in a closed storage tank. The pump is started up until the required pressure is reached, the air in the tank being compressed by the rising water level. If it is found that the water level is too high before the required pressure has been reached, a little extra air is blown into the tank from the shop mains or is provided by a small compressor. When the pressure has been reached the pump is automatically shut off and any further requirements are supplied by the expansion of the air until the pump starts again at a reduced pressure. As it is difficult to avoid small air leaks or absorption of air by the water when in service, air is added as required to " top " up of the system by either manual or automatic float control. This system can be applied to any liquid that can be stored in a tank and is applied to suds supplies when it is desired to avoid the use of by pass valves with gear or plunger type pumps.

Aftercoolers

Although in some cases it is an advantage to use the hot air as delivered by the compressor, it is found that, in the majority of cases, the air is delivered through pipe lines where the temperature will eventually fall to the shop level before use. In this case, if,

the air entering the pipe lines is delivered hot and fully saturated it will be found that considerable amounts of water are deposited during cooling and cause a great deal of trouble and annoyance. The introduction of an aftercooler between the compressor and the reservoir will help to prevent this by arranging for a drop is temperature and the consequence elimination of the water vapour. Until recent years the majority of aftercoolers have been of the water cooled type and these will be dealt with first.

The aftercooler is usually designed so that the air passes through tubes which are arranged in a water cooled casing. They are usually made in the form of the vertical cast-iron cylinder which serves as the water casing and has suitable covers at each end and provision for the entrance and delivery of the air. The tubes are secured at each end of the casing in a non-ferrous tube plate and are expanded or ferruled in position so that no air can escape into the water cooling passages. Usually the design provides for the air to pass several times up and down the length of the casing and the final delivery is arranged to take place at the point where water is coolest. With a well-designed aftercooler it is possible to obtain a final delivery temperature about 15° above that of the cooling water and consequently very little cooling taken place in the shop mains.

Where trouble is experienced with moisture in the pipe lines, an aftercooler will prove to be a very valuable addition and will justify the additional expenditure called for by the savings that can be made by the avoidance of spoilt work. This is particularly the case where the air is used for sand blasting, paint or enamel spraying and in other similar cases where oil and water free air is desirable.

Where water cooled, multi tubular aftercoolers cannot be used owing to difficulties of water supply or for other reasons, such as the small amount of air which is being handled, air cooled tubing is an excellent alternative.

Gilled tubing is now commercially available and by its use a final delivery temperature of about 100° F. is readily obtainable. A grid built up with two vertical headers connected by a number of lengths of gilled tubing arranged horizontally, will make an excellent aftercooler but it should be remembered that it is neccessary to instal it in a position which is reasonably cool and has an ample supply of fresh air. It has been found that about 100 ft. of 1½ in. gilled tube built into a grid will deal with 400 cub. ft. of free air air delivered per minute by a single stage compressor at 80 pounds per square inch.

Elimination of Oil and Water

Where careful consideration has not been given to this problem, considerable trouble is experienced due to the condensation of water in the the pipe lines and although, under some circumstances, this does not cause more than annoyance it can be easily eliminated. The question of draining pipe lines will be dealt with later and will provide a partial solution but it should always be the aim to eliminate as much water as possible before the air enters the mains. Of course, in addition to the annoyances which are experienced with wet air passing through equipment, there is always the possibility that water logged pipes will freeze up if they are exposed to low temperatures. Oil in the air supply is not such a vital problem in most circumstances but it must be carefully eliminated when the air is used for water raising, spray painting, or air blast cleaning for special work.

On a very humid day the amount of moisture held in suspension in the air is very considerable and it has been stated that a compressor dealing with 100 cub. ft. of free air per minute, at an inlet temperature 65° F., and compressing this to 100 pounds per square inch, with a final air temperature in the compressed air mains of 65° F, will have to deal with 4.1 and 2.9 pints of water, assuming 100 per cent 75 percent saturation respectively at the inlet. If such a compressor is running continuously day and night the water to be dealt with would amount to many gallons per week. This quantity of water varies with the delivery pressure and although it is slightly reduced with lower pressures, the quantity is increased for higher pressures.

To eliminate this water from the shop mains it is essential that the air should be reduced to the shop temperature before it enters the mains. Some form of aftercooler is necessary and may be either air or water cooled or, on the other hand the problem is sometimes solved by allowing a continuous flow of water to trickle over the air receiver. The most effective method is to cool air in an aftercooler and then pass it into a receiver separator.

A very successful design of the latter was arrived at after much careful consideration of the problem. The air stream flows through the down pipe and impinges on a mushroom plate in the base. This plate is supported above the base of the receiver to leave room for the separated water and oil to collect and there is a drain at the bottom for its removal. The driplets of oil and water, impinged on to the mushroom plate, are held by surface tension until they have collected and drop from the edge of the

plate to the bottom of the receiver. It is essential that the receiver should be carefully drained and a drain-cock or possibly an automatic trap should be fitted. If a drain cock is used, it can be slightly cracked so that the stream of water is continuously run off without loss of air. A disk with a very small hole fitted between the drain-cock and the receiver will break down the pressure due to the restriction of the small orifice and allow an easier adjustment of the drain-cock opening. These precautions will prove to be well worth the initial expense by the advantages gained with the use of clean dry air and will prove to be very much more satisfactory than endeavouring to remove the moisture when it has once got into the shop mains.

Air Mains and Branches

The installation of the air mains is a very important subject and must be considered from several angles if the best results are to be obtained. The size of the piping used for the connection to the receiver should never be smaller than the size of the pipe connections on the compressor and if, anything, it should be a little larger.

It is very important to consider capital cost because the amount of piping in a works may be very considerable but the capital cost should not be allowed to jeopardise the running costs. If the pipes used are too small there may be excessive pressure drop in the mains and in consequence the equipment will not give its full output so that the capital saving for piping may be more than offset by the loss of power.

Even though an efficient aftercooler is provided, it is always good practice to arrange for a slight slope of the air main in the direction of air flow and at the end of every length a collecting pipe and drain cock should be provided. In addition, all outlet branches should be taken from the top of the pipe. All changes of direction should be made with generous sweeping bends, wherever possible, in order to provide for an easy unrestricted flow of the air. Where compressed air is required over the whole of the factory it is good practice to arrange for a ring main as this has the advantage of feeding the air to any given point from two directions.

When considering a large installation, it is always an advantage to install two or more compressing units at various points in the ring main and this is particularly useful when damage due to enemy action has to be considered. Suitable stop valves placed at strategical points will enable one section of the works to be supplied with air when the remainder is shut down.

In a normal piping installation for a working pressure of 100 lb. per square inch there should not be a drop of more than a few pounds at the furthest point. The allowable loss for low pressure systems will vary, depending upon the capital cost for larger pipes. when compared with the increase in power at the compressor if higher pressures are necessary to overcome pipe friction.

PREVENTION OF WASTE

Paper presented to the Institution by
B. H. Dyson (Associate Member)

IT is almost impossible to name an industry in which waste could be completely prevented, and therefore the study and elimination of waste presents one of the greatest opportunities for the reduction of cost and the increasing of output.

In fact, a well-known and efficient works manager, when asked recently to list briefly the steps to efficient control gave as the third most important item—" Have the waste and scrap pile located outside the works manager's office window." That tip may cause a real black-out, but nevertheless we all realise that at the present time the act of wasting is directly translatable into aid for the enemy.

I intend to deal with the prevention of waste under the two main headings of :

(i) Unavoidable waste, and
(ii) Avoidable waste,

and although my remarks will apply to industry in general, I shall make special reference to the engineering industry as this is the industry in which the greatest activity is required at the present time.

CLASSIFICATION OF WASTE

		Utilisation	*Procedure*
(1) UNAVOIDABLE.	SALVAGE.		Collection. Segregation. Selling scrap. Disposing scrap.
	RECLAIMING.		Reprocessing. Rebuilding. Remaking.
	By-products.		Chemical Processing.

			Source	
(2) AVOIDABLE.	MATERIAL.			Direct. Indirect.
	LOST TIME.	LABOUR.		Direct. Indirect.
		MANAGEM'T.		Production control. Company policy.

Unavoidable Waste.

Unavoidable waste seems to have only one solution, and that is the utilisation of waste. This can be dealt with under the three divisions of

(a) Salvage,
(b) Reclaiming,
(c) By-Products.

Salvage. In order to make salvaging effective it is essential to organise the collection of all the miscellaneous waste materials, segregating and classifying them, and deciding whether it is more profitable to dispose of them at scrap value, to reclaim them, or to process them chemically for producing by-products. Even when it is decided to dispose of waste material there is always the question of whether to sell it at its basic scrap material value or to increase its scrap value. A few instances of this may be enlightening.

In the Company with which I am associated we have installed a second-hand baling machine for baling waste blanking strip from punch presses, and our scrap metal purchasing people supply their own labour to bale the material, but they pay us 10/- per ton more for the scrap material.

We have always made use of the wood wool packing from goods received by using it again for our own despatches. We recently purchased a paper shaving machine in order to utilise all our waste paper in view of the high price of wood wool, and have produced sufficient paper shavings to enable us to sell several tons of wood-wool received from incoming goods.

We used to sell scrap armatures at scrap steel prices because it cost too much to remove the copper wire, but we have now devised tooling to strip the copper wire and thus dispose of this at the high copper scrap prices.

Our scrap dirt bags from our electric cleaners were always sold to waste rag merchants, but we were able to use them for A.R.P. sandbags, camouflage, black-out screens and cleaning rags.

Reclaiming. It may often be found worth while and profitable to restore, re-work or repair salvage work and render it fit for use again either for the original purpose or for an inferior purpose.

Examples of reprocessing that we have carried out are the re-smelting of zinc and aluminium castings for use in our alloy die casting, and also the reclaiming of tricoletholine by the distilling process, and we are experimenting with the re-claiming of paint lost during spraying.

Due to the great difficulty of obtaining material and labour we have recently investigated reclaiming by welding, plating and metal spraying. In normal times, of course, welding has been used to a great extent, but even here we have progressed still further and are welding aluminium castings which were previously scrapped due to the fact that the castings cracked after welding through excessive distortion, expansion and contraction. This has now been overcome by pre-heating the defective castings before welding. We are also successfully building up worn shafts by nickel and chromium plating, even wound armatures are being successfully "built up" on the worn diameters by protecting the windings with rubber sleeves

during the plating and grinding processes. In the case of large surface areas that have worn we are successfully building up by the process of metal spraying. Broken and chipped bakelite mouldings can also be built up by pitch compound or plastic wood ; this is particularly useful in the case of stripped threads.

Re-building and reconditioning is carried out in many factories in a special re-building section. We ourselves, have always adopted this procedure and have found it very useful to make use of component parts that are functionally correct, but with a finish not up to new standard, that can be used on re-built models.

Re-making. This includes the procedure in which the short ends of tube and bar, or in many cases scrap parts, can be cut down or remade into other components. Examples are long armature shafts that can be shortened to be used on smaller armatures. In one case, we were able to save all the bar ends on a long shaft job and make from these short bail shafts. We also made short collars from the scrap ends of tube.

Possibly the greatest source of remaking is in the case of small tools such as the making of countersinks from short ends of drills, re-sharpening of files, the grinding of worn reamers to the next size, the use of worn or broken mulling cutters and saws as turning and parting-off tools.

Again we are using scrap blue prints to make thick paper collars to replace brass collars that are used to protect the splines of shafts from damage. We have also made use of all scrap cardboard by making this up into egg-box type packings.

By-product Manufacturing.

There are many examples of obtaining a profitable return, particularly in the chemical processes of coal, gas, steel and such-like industries. Indeed, the problem of the prevention of waste in some large undertakings is such that separate factories are established whose sole function is to convert the waste of the parent factory into useful by-products. Although this can be and is in some cases quite a profitable business, obviously it is only applicable to certain industries and not to a large degree in the average engineering industry, although the Ford Motor Company are producing road building slag and fertilizers from foundry waste.

Utilisation of waste has for some time received much attention in other industries ; we find that scrap ends of wood and wood shavings are used for paper making and hat making. Also, that sawdust and fibre are used for paper mache and moulding powders.

I consider that equally as important, especially at this time of material emergency, as the question of salvage and reclaimation is obviously the prevention of the necessit yfor this function, and that is

why I intend to devote the rest of this article to that side of waste.

Before leaving the question of utilisation of waste, however, I would give you one golden rule—Make quite certain that your process and procedure of utilisation is not more costly than it would be to face up to disposing of it at its scrap value—first loss may be the best loss. We have found this true in more than one case.

Avoidable Waste.

This problem of preventing waste is a question that can be controlled by management, supervision and workpeople. It is interesting to record that in the report of a committee of 15 engineers after investigating the internal affairs of 125 representative companies in six main industries in the United States, they put the responsibility for loss by waste as follows :—

Management	45 %
Supervision	25 %
Labour	15 %
Outside influence ...	15 %

Accepting this rating at any rate as a point for serious thought, it will be realised that this waste problem covers an extensive field, and I feel that it can best be segregated and considered under the three main headings of Material, Labour and Management.

SOURCES OF AVOIDING WASTE

- MATERIAL
  - DIRECT.
    - Raw material.
    - Machined material.
    - Finishing material.
  - INDIRECT.
    - Consumable tools.
    - Lubricants and coolants.
    - Cleaning materials.
    - Stationery.
    - Heat, light, power, air.
- LABOUR.
  - DIRECT.
    - Gossiping and loitering.
    - Bad time keeping.
    - Accidents and ill-health.
    - Type and grade of labour.
    - Manual labour.
  - INDIRECT.
    - Mental laziness.
    - Lack of training.
    - Office labour.
    - Unnecessary cleaning.
    - Misdirected attention.
    - Poor discipline.
- MANAGEMENT.
  - PROD. CONTROL.
    - Defective designs.
    - No definition of standards.
    - Inefficient planning.
    - Poor tooling and maintenance.
    - Faulty incentive schemes.
  - COMPANY POLICY
    - Poor purchasing.
    - Poor allocation and definition of duties.
    - Obsolete machines and equipment.
    - Poor working conditions.
    - High labour turnover.

Taking the first source, that of material, we can segregate this under, (a) Direct Material and (b) Indirect Material.

Under *Dirrct Matrrial* we have perhaps the most glaring forms of waste, simply because they are the most obvious. While I will agree that it is still waste, I often feel that the odd ends of bar or 6.B.A. screws, that are glared at on the floor are, after all, just the smalls, when compared with the other forms of waste. There is no denying the fact that glaring waste is present in practically all direct processes right from the mining of the ore or felling of the tree, to the finish plating or painting of the completed product.

Possibly some of the most amazing figures are those given by Dr. C. R. Engelbach who stated that in twelve months the Austin Motor Company purchased 68,000 tons of direct materials, and in order to finish this into completed cars, 14,000 tons of indirect material were used, plus 64,000 tons of material for power, fuel, etc., making a total of 146,000 tons of material. The total weight of the goods sold in completed cars and spare parts was 33,000 tons, so that by simple arithmetic it will be seen that the loss in tonnage was 113,000. In other words, 26 % of the total material constituted the finished product. In fact, a useful formula to check factory efficiency is

$$\frac{\text{Finished weight of unit}}{\text{Raw material weight of unit}} \times 100$$

Raw Materials.

It is fully appreciated that in manufacturing the simplest pressing from strip, or the complicated aero engine cylinder from the solid steel, there is during the various processes a waste of raw material, and therefore the aim in preventing raw material waste lies in the skill of producing the raw material to the nearest possible size of the finished requirements.

It is for this reason that die castings, stampings, hot pressings, forging, extrusion, roll forming, and moulding have been developed to the present stage. Even in these processes, much can be done to avoid material waste. The old days when a stamping or forging of the crude shape was sufficient are passed, but incorrect designs of the component or tools, and faulty set-ups and maintenance of the tools result in a heavy waste in the form of tag ends and flash.

Again, with die casting, incorrect set-up or failure to keep die faces clean, or incorrect lubrication, will result in thick flashes of waste material.

With bakelite moulding also, incorrect tool setting and faulty measuring of the powder will result in heavy flashes of raw material at the tool jointing faces.

Machined Material. In the first place, rod and bar of the most economical size should be procured and facing and parting off cuts should be standardised to minimum ; at the same time the fullest

use should be made of drawn and extruded sections. In many cases heading or upsetting operations can be performed on rod in order to accommodate local larger diameters. We have used this method on armature shafts, resulting in a major saving on material and machining time. Setting up for machine operations is often a source of waste, and this can be overcome to a large extent by using master samples and setting up gauges to avoid the "trial and error" method which results in the waste of much material.

In the case of strip and sheet material, here again incorrect machine set up is the major cause of waste. Dull or missaligned guillotine blades result in burred edge strip, and poor location of sheet will result in strip of uneven width; both faults will cause waste due to it being impossible to pass the strip through the press tools.

The starting and finishing end of strip material during press operations if not correctly located and controlled will result in waste.

Again, with roughing, finishing and polishing operations, a high percentage of waste can occur through incorrect dressing of wheels or using the wrong grade of wheel.

All wheels should be turned concentric to the bore before dressing and marked with an arrow to denote the direction of rotation. It is important that when wheels are being dressed this should be done in the same direction as the wheel will run in use.

Finishing Materials. Finishing operations such as sandblasting, metal spraying, painting and plating, although not so obvious, often show on investigation the most appalling waste. With sandblasting it is essential to use the correct class and grade of grit or shot. A waste of shot can be overcome by fitting a fine wire gauze baffle over the suction take-away pipe in order that the unused shot is not sucked away with the dust and dirt. The glass of the vision window and light in the sand blast cabinet should also be protected with gauze to obviate blast and consequent frosting up.

With metal spraying, much waste of metal, also gas and air used in the process, will occur if the work is not properly prepared beforehand with a good keying surface, and therefore, the abrasive used must be angular and not round. It has also to be realised that the metal being sprayed is only moulten for a fraction of a second and the operator must be trained to position his gun correctly. In fact the prevention of waste is largely controlled by the operator's dexterity.

Correct air pressure and the correct volume of air is necessary in order to overcome waste, because low pressure will produce a glossy finish, indicating low keying properties. Also, excessive

speed of wire feed will result in a lumpy, finish due to insufficient time to fuse correctly the wire, resulting in wire wastage. This should be checked occasionally by calculating the surface area, and the thickness of the layer covered with a spool of wire—the loss should be within 15 % to 20 %.

In the case of paint spraying, here again waste is to a great extent only controllable by the spray operator, and an occasional check of surface area painted and paint used should be made. It is well to check on the area of the article being sprayed in relation to the total area of the spray from the paint gun. Much can be done, however, in designing holders for the components to be sprayed in such a manner as to utilise the whole area covered by the arc of the spray nozzle—We have done this successfully on fuse bodies, etc.

In the plating department waste is mainly due to anode wastage caused by incorrect current and poor contacts as well as inefficient supporting of the articles to be plated. It is, of course, worth while to have plating racks insulated with either bakelite sheaths or by tapering the racks and then coating the tape with bakelite varnish in order to prevent waste by the deposit and also to overcome fouling the work-holding rack.

Indirect Material. The waste of indirect material is not always so apparent, but none the less present, and often to a high degree responsible for high manufacturing costs.

It has to be appreciated that even with the largest automatic or planing machine, the part actually doing the work is a small consumable tool. The ordinary twist drill is perhaps the most used consumable tool, and I think it safe to say that 50 % of drill life is wasted.—How many are actually worn out?—they are mainly broken or ground away through incorrect sharpening. It is seldom appreciated that to hand sharpen a drill is a specialised job, and centralised drill sharpening on a drill grinding machine is the most economical.

Again with taps, the greater part of their life is wasted by breakages and poor grinding.—How many firms have a special purpose tap re grinding machine and really use taps to the end of their useful life?

The major portion of the life of a milling cutter is wasted due to running at an incorrect speed and feed, or the hit and miss use of a coolant; often more so by the cutter being bumped into the work on feeding in, by not being positioned on the arbor close to the milling machine to ensure rigidity. Also by not being driven by a key to prevent slip wear, or by being ground or used on an arbor that is not true, thus throwing all the work on one or two teeth. Again, with turning tools incorrect grinding and lack of rigidity in setting up and supporting is the main cause of waste. Lubricants and cool-

ants are wasted mainly by the fact that they are misapplied; we invariably see oil plastered over strip metal during press operations by means of rag or a brush instead of being applied by passing throug.. oil feed rollers, or much better still, by an oil spray on an air line just at the point and time of the press operation. With drilling, tapping and milling operations the hit and miss brush application of lubricants or coloants invariably wastes much more than is actually effectively used.

In cases where lubricants and coolants are fed to the work by pump from a sump waste usually occurs through making a change of the sump contents too infrequently. This causes the oils to become thick and lifeless, whereas with frequent changes the oils can be reclaimed by purifying and cleansing, and thus used again. Often one finds a great deal of oil wasted in the removal of swarf from the machines, and the installation of centrifugal equipment to clean the swarf and reclaim the oils is beneficial.

Cleaning materials are often difficult to control. Rag and waste used for cleaning is invariably issued from the stores on requisitions, and I have yet to see a store where this is weighed out. What usually happens is that the store lad dives into the sack or box of rags and hands out according to his likes or dislikes of the bearer of the requisition, or according to how much rag is in the store. This can be better controlled by purchasing rag from suppliers who put it up into paper bags in known quantities from 1 to 5 pounds. The chemical cleaning materials are often wasted because of wrong application and by evaportaion. Far too often they are used by operators for cleaning hands, etc.; this should be avoided by supplying a recognised commercial hand cleaner as, of course, apart from waste of the chemical cleaner there is the great danger of industrial diseases through the natural protective oils of the skin being ruined.

Both in the office and factory one can always see colossal waste of stationery—there often seems to be a total disregard of the fact that stationery has to be bought and paid for. First of all, there should be one person through whom requests for all printed forms, etc., should pass in order to check on whether these are really necessary and to avoid duplication. Where forms are printed with a multitude of copies a periodical check should be made to ascertain if all the recipients actually make use of them. We have found that at least 25 % are never used, and also that the size of most forms can be reduced by one-third.

It is an excellent plan to supply each department with a stationery issue record card for either a weekly or monthly period instead of the usual requisition form. This method brings to the notice of the person authorising the request for stationery when and how

much has already been used, and also at the end of the period the cost of the issues can be shown.

Heat, power and light are often an unnoticed source of waste—for instance, clean boilers are great fuel savers. Remember that $\frac{1}{8}$th of an inch of soot deposit renders a heating surface practically useless, and $\frac{1}{16}$th of an inch of scale or sediment may cause a loss of 12 % of fuel. Bad firing of a boiler can increase fuel consumption by as much as 15 %.

When electric power is used, especially if it has to be paid for on the maximum K.V.A. basis, an hourly check must be made in order to obviate peak period loads.

Frequently many power driven machines are left running when not in use, and during meal breaks. There is also the colossal unnecessary ill-use of lighting in private offices as well as manufacturing shops. To circularise memos and have posters drawing attention to the value of electricity that is being used will often help. Notices can also be affixed above switches asking for care to be exercised. With machines that are used intermittently, such as grinding machines, it is a good idea to have the light switch operated in conjunction with the power switch, so that the light will only be brought into use when the machine is actually being operated.

Labour.

Here again we can segregate and consider waste under the Direct and Indirect headings :

Direct Labour. It is this waste of human effort that perhaps gives the most need for thought from departmental heads, as much can be achieved by correct supervision. If we waste a piece of material costing one shilling it is one shilling's worth wasted, but if we allow one shilling's worth of wasted time the reaction of this will invariably cause a repercussion of a much more costly nature.

The most obvious side of this waste of human effort is caused through gossiping and loitering, ranging from excessive misuse of cloakrooms, filling in the football coupons and discussing the previous night's blitz ! Eating and drinking during working hours is another cause, and apart from the fact that it creates an untidy appearance, it is unhealthy and, in fact, the eating of fruit by operators working on instruments involving electrical contact faces has caused many rejections. The provision of recognised rest periods will overcome these troubles and be beneficial to employer and employees. Often, it is the less obvious loitering and gossiping that accounts for waste such as time wasted in hunting for misplaced tools and equipment. The amount of time wasted looking for spanners, wrenches, nuts, bolts, packing pieces, etc., is amazing, and I strongly recommend a rack on each machine to hold the tools special to that machine, and

portable supply trolleys for machine set-up and maintenance work. It is also a good idea to paint the background of these tool racks and trolleys, leaving the area covered by the tool when in position unpainted, in order that it can immediately be noticed when missing Again, time wasted at stores windows getting material, bins, drawings tools, etc., can be overcome by delivering the material, the empty bins for the completed work, drawings, tools, etc., all ready to the machine on which they are required, by the Progress Department's internal trucking service.

Bad time-keeping is another source of direct labour waste and obviously this entails waste machine hours, and where machine and labour work loading is applied, this often seriously upsets production programmes. The scheme of giving half a day off with pay for a clear month's perfect time-keeping and without absenteeism has much to commend it.

Accidents and ill health cause much direct labour waste. Accident prevention guards should be so designed to be interlocked with the starting up of the machine, or actuated by the feeding mechanism in order to avoid time waste in operating.

The question of using the correct type and grade of labour is important. If direct labour of too low a grade is used the standard of work will suffer and again if labour of too superior a grade is used it is a direct waste of human material and obviously costs are affected.

Again, with direct labour the question of machine operators doing clerical or labouring work is a waste that cannot be tolerated in view of machine tool capacity. On several occasions we have been able to increase machine tool output by investigating and eliminating a large percentage of the work normally carried out by the machine operator.

By laying out the operator's work place with motion economy principles of having the work delivered or placed within correct radial position, and with tools in a known fixed position so that both hands are employed on productive work, we have obviated up to 40 % wasted effort and time.

Indirect Labour. I often feel that while the question of indirect labour waste is attacked in the workshop, the same waste is accepted without question in office and clerical departments. These departments should be made to realise that they are Service departments to direct production and, in fact, to warrant their existence they must, in some manner or other, assist direct workers to carry out their work more efficiently. Many so-called non-productive departments are often the source of the waste of mental effort, and much can be done to turn these sections into what they should be—Production Service departments.

Possibly the greatest cause is insufficient information on drawings, frequently the consequence of mental laziness, resulting in continual enquiries as to the interpretation of the drawing.

It has to be realised that when machine or assembly operators have to make calculations, add up dimensions, look up conversion tables and fit limit tables, etc., that this is waste of mental effort. When speeds and feeds have to be calculated in the shops, or more often than not—guessed at, it will be observed that the old-fashioned brass plate on machine tools is either unreadable or never referred to, and would be better replaced by a multi-colour or code control indicator.

Inexperience, especially that due to lack of or insufficient or inefficient training is a gross source of waste. Far too often a workman is given a job without any explanation or guidance on how or what has to be done, and it is amazing to find that quite often an operator is left in ignorance as to the quality of finish required, or how long he is ex ected to spend on the job.

Although I have a kink for tidiness and cleanliness, I do feel that there is much unnecessary cleaning carried out. It is surprising how many brass name plates, door knobs, taps, window latches, copper urns, pipes, control wheels, etc., are labouriously polished, when either with a coat of laquer or chromium plating all this could be obviated.

The sweeping of workshop floors can be accomplished much more easily and quickly if bench feet are only braced with one lengthwise brace at the base in order that one open side gives access to sweeping. We have arranged that all assembly benches have one lower brace which also acts as a foot rest, and is high enough to allow a broom to pass underneath. There are also many efficient floor applications to render wood and concrete floors free from dust formation, and obviously walls, ceilings, pillars, etc., are much more easily cleaned if they are well painted with a good hard gloss surface. We investigated this and found a 40 % saving in washing-down time. Again mechanical, electrical and suction cleaning apparatus could be made more use of in industrial plants and offices.

The point of misdirected attention is often difficult to locate, and it can be a breeder of waste material, time and effort. In this category I refer to such things as putting a finish of accuracy and surface on a job far in excess of what is required ; making an elaborate drawing, tracing and print, when a sketch would suffice.

Time studying a job when only a dozen or so components are required, or motion studying a job when the quantity is small and not to be repeated ; the making of elaborate tools for simple operations, where the quantity does not warrant it ; the inspecting of dimensions and finish where this is of not great importance.

Take, the sorting and segregating of parts from swarf which can be accomplished automatically on the machine, such as by fitting work and slug deflectors on presses, and the use of deflectors on automatics and capstans, also by the use of sieving and sorting machines and swarf removal devices.

Lack of discipline will cause labour waste to be rife, the chief reasons being late starting of actual work in the morning and after breaks. Operators should be expected to be ready to start work when the signal warning sounds, and not just arriving or clocking in. Early ceasing of work to rush to tea waggons, or at meal breaks and closing time often amounts to considerable waste of time.

Much of this type of waste can be cured by instituting a sound merit award scheme of increasing hourly rates in stages of 1d. per hour on a monthly record of operators good conduct, or of deducting a like amount where necessary.

Production Management.

Management's part in the elimination of waste can be considered under the two headings of Production Control and Company Policy and I feel that it is of little use blaming and kicking all and sundry causes of waste in the manufacturing departments if mismanagement is in existence.

The cradle of production costs is invariably the design and drawing office and the keenest watch should be kept on this aspect, for any waste due to inexperience or waste of mental effort will cause ever recurring waste. Designing for ease of production demands that the people engaged on design have intimate and up-to-date knowledge of the production facilities available, and of production methods. Unnecessary limits, specifications and finish are, of course, important, but equally important also are unnecessary flat bottom of blind holes.

A definition of standards is most important and where these cannot be laid down by dimensional limits or functional tests samples should be available demonstrating the allowable tolerances. If this is not done untold waste can result in variations and fluctuations of personal opinions, particularly where the question of surface finish and appearance, noise, and vibration are concerned. Such examples that often arise are how tight is tight ; how loose is loose how straight is straight ; how smooth is smooth, etc.

In many cases we have increased output by re-designing as follows:

(a) Using diecastings instead of extruded strip and turned parts.

(b) Spot welding instead of drilling and rivetting.

(c) Locking nuts by staking instead of drilling and using split pins.

(d) Zinc plating instead of cadmium.

(e) Printing instead of branding ; stamping and branding instead of engraving.

(f) Embossed lettering instead of sunk lettering for ease of die making and also to obviate filling in.

Remember that the famous Bofors Anti-aircraft gun is now being made at 1/6th the price by fabricating methods instead of forgings. The Bren gun has been redesigned with the result that a 20 % saivng in labour hours has been achieved.

Efficient production planning can save its cost a hundred fold if correctly applied. In the first place, standard size material is cheaper than special sizes and supplies are less likely to be of a long delivery date.

By efficient planning waste in set-up can be obviated by arranging that similar jobs are lined up in sequence, and that there is not continual cleaning of machines because of material being different on every job. One of the greatest eliminations of waste can be accomplished by having subsequent jobs lined up for every machine and operator, with material, tools, drawings and containers for finished work all ready and waiting.

Stores planning must also be watched. The stores being the custodian of internal stock value, it can aid waste prevention by issuing correct materials, assisting in maintaining stocks to an economical level, preventing over issue or under issue of material or parts. The stores must also watch that stock is stored correctly to guard against damage by explosion, heat, cold, vermin, or breakage. Planned storage will ensure that stocks are issued in rotation to receipts in order that early incoming goods are not left at the very bottom of the bin to deteriorate while late deliveries are being used. Also the storage must be such that the most called-for stock is nearest the serving counter. Despatch planning can overcome waste by ensuring that goods are shipped by the most economical route. Insufficient packing can entail heavy losses, but it is just as foolish to overpack, and therefore standard packing procedure should be laid down. A full list of transport rates in relation to size, weight and distance should be displayed in the Despatch department. References should also be made of special concessions, extra charges for special materials, or express deliveries.

Company Policy.

Poor purchasing with lack of foresight and initiative can cause untold waste. Often far too much 'office chair' purchasing is attempted instead of actually getting out and around on the job.

Castings, forgings, mouldings, etc., should always be purchased by unit price instead of by weight or otherwise the result is to pay for excess material, which again has to be paid for by machining off. Placing long term orders for gross quantities and arranging for periodic deliveries has advantages, and it is also important to obtain alternative sources of supplies.

It has been my experience that much duplication, many frayed nerves, heaps of heated arguments and much misdirected attention are due to poor allocation and definition of duties of departments and individuals. One so often finds that there is no true and laid down chart of responsibility and authority. I consider that it is well worth while to amplify the usual family tree chart by defining the activities of the individuals.

Possibly at the present time one is on dangerous ground to talk of obsolete machinery and equipment, although we have to remember that if we are cursed with this at the moment it is in all probability our own fault for not giving this matter attention a few years ago. But even at the moment it is well to take stock and record the condition of machine tools in order that they can be made most use of by allocating the type of work that can be undertaken by these machines.

Poor working conditions will obviously result in waste of macihne and labour capacity; poor lighting, heating and ventilating insufficient sanitary and washing accommodation, inadequate facilities for medical attention and accident prevention, and poor accommodation for meals, will come under this heading.

High labour turnover, occupational misfits and lack of training, excess overtime or short time are nowadays almost a crime. Apart from loss of production it has been estimated that the cost of every new employee varies from £10 to £25, therefore it pays to record and investigate terminations—Why did it occur?—Was it due to internal inefficiency, lack of training, working conditions, or was it for the purpose of advancement and promotion from outside?

Vocational tests for new employees, although not infallible, are proving reasonably correct, and give good indications of suitability and adaptability.

One word of advice on training: ensure that it is known and laid down what training is to be given and how it is to be given. Above all, define the training—nothing is worse than the trainee receiving haphazard and contradictory instructions. We have overcome this by laying down a training syllabus, and a simply worded "Help Yourself" training booklet which is the basis of training given.

As final advice I have found from my own experience six sources that can form the basis of your investigation of waste prevention, and I hand them on for what they are worth.

Watch—

1. Waste paper baskets.
2. Scrap heaps.
3. What employees are carrying.
4. Groups of work people.
5. Non-productive time records.
6. Enquire on the activity of all persons passing a chosen position.